DTU Library

S2-imaging of Bessel-like Beams

Ingerslev, Kasper; Israelsen, Stine Møller; Rottwitt, Karsten

Publication date:
2013

S^2-imaging of Bessel-like Beams

Kasper Ingerslev[1], Stine H. M. Larsen[1], and Karsten Rottwitt[1]
[1]DTU Fotonik, Technical University of Denmark, Kgs. Lyngby, DK-2800, Denmark
s103112@student.dtu.dk

Bessel-like beams generated in a double cladding fiber are characterized for the first time using S^2-imaging. The wavelength independence across the beam is examined numerically.

Higher order modes; Characterization

I. ABSTRACT

Spatially and spectrally resolved imaging (S^2) is a method of measuring modal content, and their individual power levels in optical fibers. It excels by having a high sensitivity and requiring no assumptions about the fiber under test [1]. Bessel-like beams has the unique ability to self-heal, and has many applications including data transmission and as optical tweezers [2]. In S^2-imaging, it is assumed that the relationship between the power of the co-propagating modes is independent of the wavelength [1]. This assumption is explored numerically. Finally, an S^2-measurement is made on a double cladding fiber where a Bessel-like LP_{010} beam is excited using a long period grating (LPG) [3].

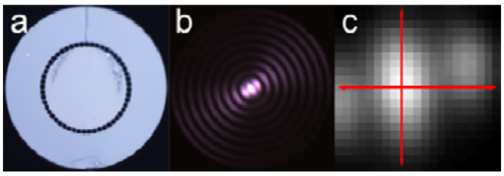

Fig 1: (a) Microscope image of the fiber. (b) Image of the mode. (c) S^2 image of the core, marked with line directions.

The fiber under test is a double cladding fiber, where the outer cladding is an aircladding and the core is singlemoded, a microscope image of the fiber is depicted in Fig. 1a. The modes of the fiber are calculated using a scalar mode solver. The ratio of the field amplitudes of the weak mode and the dominating mode is called α. This is a key parameter in S^2. The deviation in α, relative to the mean α value is plotted in Fig. 2, as a function of radius. It is found that in areas with LP_{010} intensity above -10 dB, relative to the beam center, the deviation in α is below 12%. Thus the deviation is only significant in areas with low light intensities and this effect is thus negligible. Modeling is done using a 100 nm spectral range, where α is linearly dependent of the wavelength.

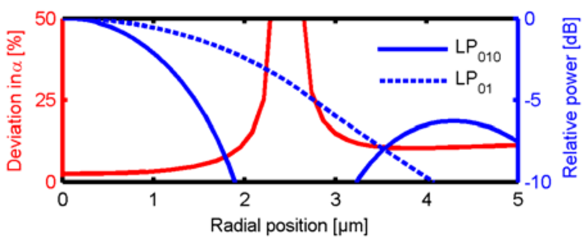

Fig 2: Deviation in α and intensity profiles for LP_{01} and LP_{010}.

The Bessel-like mode, LP_{010} is excited with a LPG with a 99% conversion efficiency and guided in the inner cladding. Fig. 1b shows an image of the mode. The mode content in the core is scanned in a square grid as an overlap of the two modes only exist here, thus characterizing how much of the fundamental mode remains. This is plotted in Fig. 1c. From the figure, the dominating mode is clearly Bessel-like. Analysis shows that the remaining mode content is primarily the fundamental mode.

Assuming that the mode excited by the LPG is azimuthally symmetric, the mode content in the inner cladding is imaged along a vertical and a horizontal line through the intensity maximum, allowing for faster imaging. In Fig. 3, the line scans along the axes are shown. For both directions, we see a central peak and 9 rings, rings indicating that the dominant beam is a LP_{010}.

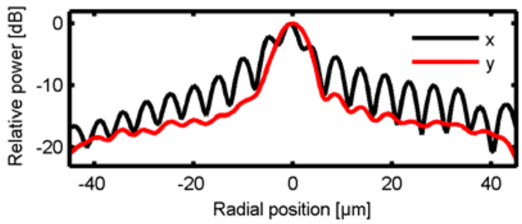

Fig. 3: Line scans along the axes of the beam.

In summary, we have demonstrated that the wavelength independence across the beam is valid within the high intensity regions, and that the S^2-method may be expanded to large area higher order modes.

A. *Acknowledgement*

NKT Photonics is acknowledged for manufacturing the fiber. The group of Professor Siddarth Ramachandran at Boston University is acknowledged for facilitating the manufacturing of the LPGs.

REFERENCES

1. J. W. Nicholson, A. D. Yablon, S. Ramachandran, and S. Ghalmi: "Spatially and spectrally resolved imaging of modal content in large-mode-area fibers," Opt. Express 16(10), 7233–7243(2008).

2. A. Dudley, M. Lavery, M. Padgett, and A. Forbes: "Unraveling Bessel beams", Optics & Photonics News 24(6), 22–29 (2013).

3. H. G. Park, and B. Y. Kim: "Intermodal coupler using permanently photoinduced grating in two-mode optical fibre," Electronics Letters 25(12), 797-798 (1989).